Chapter 1
Causality:
The Next Step in Artificial Intelligence

Luis Cavique
https://orcid.org/0000-0002-5590-1493
Universidade Aberta, Portugal

ABSTRACT

Judea Pearl's ladder of causation framework has dramatically influenced the understanding of causality in computer science. Despite artificial intelligence (AI) advancements, grasping causal relationships remains challenging, emphasizing the causal revolution's significance in improving AI's understanding of cause and effect. The work presents a novel taxonomy of causal inference methods, clarifying diverse approaches for inferring causality from data. It highlights the implications of causality in responsible AI and explainable AI (xAI), addressing bias in AI systems. The chapter points out causality as the next step in AI for creating new questions, developing causal tools, and clarifying opaque models with xAI approaches. The work clarifies causal models' significance and implications in various AI subareas.

1. INTRODUCTION

The causal revolution heralded by Judea Pearl [Pearl 2000], [Pearl, Mackenzie 2018], [Pearl 2019] caught the attention of disciplines such as causal discovery and causal inference. Causal discovery aims to infer a causal structure based on observable data. In other words, given a dataset, find the causal model usually represented by a direct acyclic graph. Causal inference comprises a set of tools that allow data analysts to measure cause-and-effect relationships. In a complex world, causal inference helps establish the causes and effects of the actions studied, for example, the impact of minimum wage increases on employment or the influence of legislation on the number of enrolled students.

In the current era of Big Data, the evaluation of data-driven models favors more explanatory models than just predictive ones. The difference between correlational and causation is at the heart of the controversy over prediction and explanation. These two tasks must be distinguished for Artificial Intelligence (AI), giving rise to new disciplines such as explainable AI (xAI) [Belle, Papantonis 2020].

DOI: 10.4018/978-1-6684-9591-9.ch001

Objectives

This work has two objectives. Firstly, clarify the concept of causality, exploring the cause-and-effect relationship between variables. Then, the research aims to highlight how grasping causality impacts the current advancements in AI.

Contributions

Beyond the contribution of an integrated view of causal models with xAI, two incremental contributions are proposed. The first is related to the new taxonomy of causal inference approaches. The second regards identifying the current and emergent groups of techniques in xAI.

Organization

The structure of the rest of the paper can be summarized as follows. Section 2 covers some background information. Section 3 introduces the subject of causality and relevant definitions. Causal discovery is presented in Section 4. Causal inference is developed in Section 5. In Section 6, responsible AI and explainable AI are presented as a consequence of causality. Finally, in Section 7, we draw some conclusions.

2. BACKGROUND INFORMATION

This work aims to present a comprehensible data science maturity model that includes the well-known business intelligence and analytics areas, the new practices in business experimentation [Thomke 2020], and Pearl's latest ideas on causality [Pearl 2019]. The proposed pipeline can be scratched as BI → BA → BE. The proposed maturity model named IABE is the Intelligence, Analytics, and Business Experimentation acronym [Cavique et al. 2023].

In this section, three crucial components of Data Science have been detailed: Business Intelligence (BI), Business Analytics (BA), and Business Experimentation (BE), which includes causality concepts.

Data Science is the current term for the science that analyzes data, combining statistics with machine learning/data mining and database technologies to respond to Big Data's challenges.

The modern Data Science developed in the 2010s corresponds to the merges of several areas during that time [Davenport 2014]:

- in the 1960s, Machine Learning, ML,
- in the 1970s, Decision Support Systems, DSS,
- in the 1980s, Executive Information Systems, EIS,
- in the 1990s, Online Analytical Processing, OLAP,
- in the 2000s, Business Intelligence and Analytics, BI&A,
- in the 2010s, Big Data and IoT,
- and finally, in the 2020s, the rise of BE and causality.